Mobile Technologies in the Management of Disasters: the Results of a Telemedicine Solution

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ABSTRACT

Nowadays a great number of applications are used to compile and transmit casualties and disasters information but there are many troubles associated with the technology as can be the communications reliability and the size and weight of the devices medical staff has to carry with. Telecommunication infrastructures support information movement among geographically dispersed locations. Recently a large family of little devices has appeared in the buyer's market. They are called Personal Digital Assistants and because of their physic and technical features, they are very useful in the emergency field. As for the communications reliability, many technologies have been developed in the last years but it is necessary to find a solution that can be used in whatever situation independently of the emergency circumstances.
Facing this reality, the Spanish government funded REMAF, an ATYCA (Initiative of Support for the Technology, Security and Quality in the Industry) project. REMAF joined research groups (UPM), phone operators (Fundación Airtel Móvil) and end users (SAMUR) to build a disaster data management system conceived to use modern telemedicine systems to optimize the management in these situations, taking the advantage of the above mentioned mobile communication tools and networks.

INTRODUCTION

Catastrophe situations are emergencies where the number of victims overwhelms the available resources. In the event of a major accident or disaster, the responsible Health Emergency Co-ordination Center (HECC) must know exactly the updated information about the number, type of injuries, name and location of the victims that has to be immediately communicated to the related emergency services and to the authorities in charge of the situation, as well as the location and status of all the available resources (doctors, paramedics, ambulances, helicopters, etc.).
The management of emergency situations is a complex matter: the inherent unpredictability of the situation joined to the fact that the involved agencies and actors usually belong to different organizations creates confusion when the magnitude of the event becomes the so-called catastrophe. The need of coordinated actions is essential for the organization, professionals and victims[1].
Currently, in these cases, the communication among actors is by voice and through manual reports from the ambulance to the receiving hospitals and the HECC. This can generate confusing information about the victims and the needed resources.

SYSTEM DESCRIPTION

In case of major disaster, a problem of identification and tracking of the victims arises. The predefined procedure in Spain for the rescue and assistance of the victims is as follows: at the accident spot victims are categorized through the triage method that consists of assigning a color code to the victim depending on the injury[2]:

- *Red*: patient requires on-site resuscitation and stabilization prior to transport.
- *Yellow*: requires treatment, but not active resuscitation.
- *Green*: minor or uninjured. Does not require treatment prior to evacuation.
- *Black*: deceased.

Luggage type labels are provided in the appropriate color. They are numbered and this number can be used as identification. After this process, victims will be transported to the reception area where most of the treatment is given; this area is called Advanced Medical Site (AMS). From here the patients will be evacuated to several different hospitals and emergency centers.
It would be of great value to be able to know where the patients are and how many patients are currently at the reception area or are being transported. This information could be gathered from the HECC, together with information of available resources at the different medical facilities, so that patients can be divided among the hospitals. This will allow an optimal use of the available resources.
The telemedicine solution presented in this paper is composed by Mobile Triage Units that are held by the rescue team at the disaster area, the Medical Admission and Dispatch Station installed in the AMS and the high reliability communication system (see figure 1).
The functional specifications and user requirements were elaborated in collaboration with the Emergency Medical Service SAMUR of Madrid.

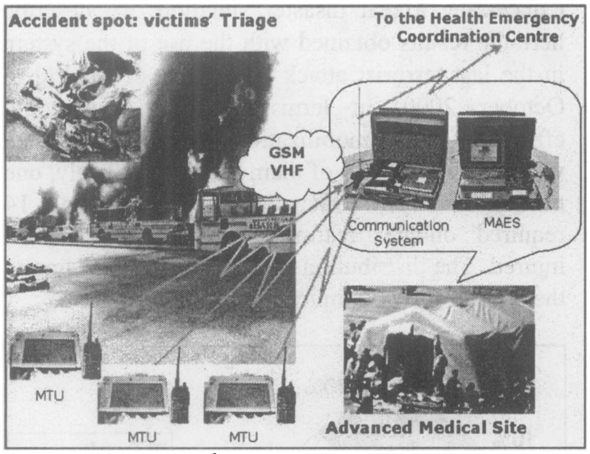

Figure 1. System Architecture.

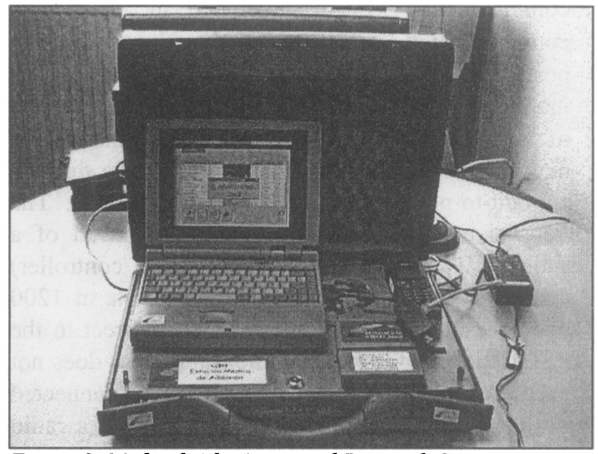

Figure 3. Medical Admission and Dispatch Station.

Mobile Triage Units (MTU)

The Mobile Triage Units have been conceived to register the victims' data (identification number, type of injuries, transportation priority, personal data and location) at the accident spot and transmit the information back to the AMS (see figure 2). The MTU are based on the light personal digital assistant Cassiopeia PA 2400 with in built data communication system and GPS[3] receiver so that position of the rescue team can be tracked at the AMS for a more effective management of the medical resources on the spot.

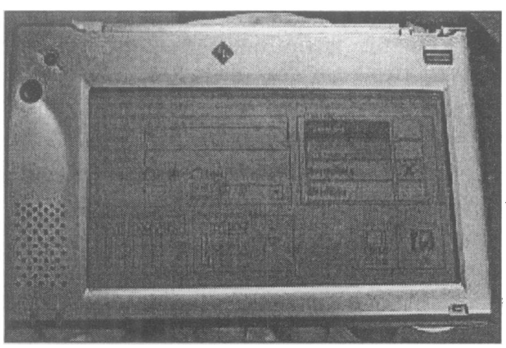

Figure 2. Mobile Triage Unit.

Medical Admission and Dispatch Station (MADS)

The MADS (see figure 3) is a workstation with a GIS database that allows the operator to know the different access paths (roads, streets, etc.) from the AMS to the disaster spot, the position of the medical resources (ambulances, medical staff, etc.) deployed in the area and the medical resources available for the patient destination assignment.
Its main functions are:

* To count and control the casualty victims. To do this, it receives directly the data captured by the officers in charge of making the Triage. In the same way, it allows the classification of the victims by categories, transportation priorities, admission time, etc.;
* Prioritize the evacuation;
* Search for the most coherent destination to the patient;
* Assign the evacuation resource to the patient.

The main task assigned to the MADS is to search the most coherent destination to the patient. The assignation criteria are:

* Appropriate center: there is a specialized service for the type of injury suffered by the victim.
* Equity criterion: patients are distributed among the hospitals according to the possibilities of the different centers.

High Reliability Communication System

Telecommunication infrastructures support information movement among geographically dispersed locations. In a disaster situation it is necessary to guarantee the communications whichever the circumstances are. Wireless linkages can provide communication less dependent of local telephone and electric infrastructures. Consequently, damage to infrastructures by disasters has minimal effect on wireless communications[4].

The communication system developed is based on a mobile access network that allows selecting in every moment the most adequate network giving service in the disaster area. It incorporates two solutions:

Communication system based on GSM

The MTU transmit the victims' data via GSM to the MADS. To do this, the PDA is connected to a mobile phone with in-built modem. Likewise, the voice and data transmissions between the Advanced Medical Site and the Coordination Center are carried out using GSM protocol.

Communication system based on VHF

There is no doubt that GSM is the mobile cellular system most world-wide extended and providing larger terrestrial coverage than other mobile technologies, thus it is the best election to guarantee the communications[5]. However, damage to radio towers, base stations, and repeaters can disable communication. As another alternative, the communication system developed incorporates a communication network based on mobile and portable transceivers in the VHF band that allows interconnection with the computers independently of the existence and/or operation of the public networks. The MTU transmit now the data through a point-to-point connection with the MADS. The transceiver of the triage units is composed of a walkie-talkie with TNC (terminal node controller) that uses AX.25 protocol to transmit data at 1200 bps. The connection with the PDA is direct to the RS232 port and the size of the transceiver does not exceed a mobile phone. A Linux server is connected in the same network than the MADS with a radio interface connected to a mobile equipment with an external TNC that receives the data from the portable triage units (see figure 4).

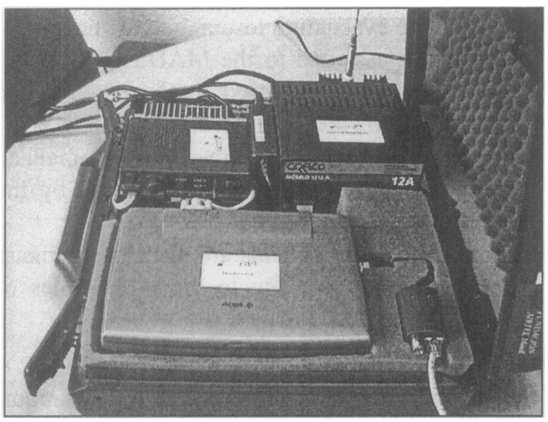

Figure 4. Communication system.

RESULTS AND DISCUSSION

Due to the high complexity of the situations arising from a disaster in the real life, the evaluation of the system has been performed in two steps and scenarios: laboratory tests for the communications reliability and real scenarios covering different activities (sports, catastrophe simulations, terrorist attacks and the last one in January in the relief activities carried out after the earthquake in El Salvador).

Regarding the communications trials at the laboratory, a total of 50 communications have been performed using simultaneously 3 Mobile Triage Units and the MADS. Non-transparent GSM calls at 9600 bps were used to transmit the data. The 96% of the connections were successfully established. The mean time required for establishing a communication was 40 seconds; the minimum value for this period was 34 seconds, when only one attempt was needed to establish the GSM call. Once the connection was establish with the first Triage Unit the MADS started polling the other two. Using VHF, the calls were established at a rate of 1200 bps and all the connections were started up.

Concerning a real disaster situation, we describe here the results obtained with the use of the system in the last terrorist attack in the city of Madrid in October 2000, in terms of time saving and efficiency in the mobilization of resources. There were 67 victims, two of them died immediately, one needed imminent evacuation to the hospital, 14 required on-site treatment and 50 were minor injured. The distribution of the victims according to the type of suffered injures is shown in figure 5.

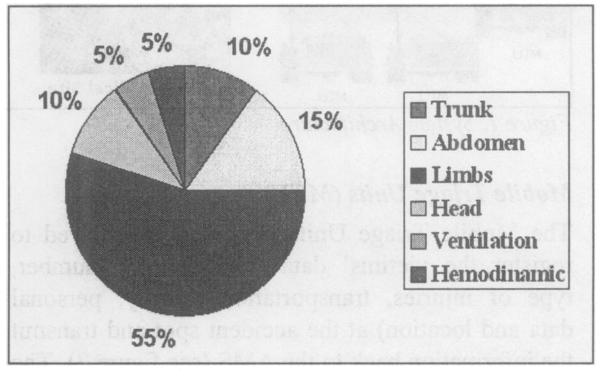

Figure 5. Type of injures percentages.

The communication infrastructure deployed for that event was VHF. The time employed by the three triage officers for doing their work was about 2 min. per victim. Consequently, the time used by the MADS to receive all the data was 44,6 min (total time for the triage) plus the transmission time (t_x). Using VHF, the data of one patient is transmitted in one second (the maximum size of a triage card is 180 bytes). Considering that while they are registering victims the system is transmitting, t_x is negligible. The total time for the coordinating Emergency Medical Service to know exactly the number and type of victims in the advanced medical site was 44,6 min. During this time they could organized the evacuation according to the existing victims and injures suffered. Without the system, we have an additional time that depends on the distance among the victims and the AMS location. This distance was about one hundred meters. It took 4 min. per patient to be transported to the AMS. The total time employed to transfer all the patients was 45 min. that is the extra time we have to add to start the organization of the evacuation.

Another result concerns the efficiency in the mobilization of resources. In this case, and according with the injury patterns received, they knew in advance that there was only the need of having one mobile intensive care unit and 14 ambulances. With a traditional disaster planning response, the evacuation of victims is done without knowing exactly the kind of resources needed until all the patients have been received in the AMS.

CONCLUSIONS

The application of Telemedicine and Telematics to the management of disaster situations represents a great improvement in medical delivery in critical situations for the human life. This new conception of an evacuation platform for major disasters assures a faster rescue process thanks to the time saved through the continuous intercommunication among the different heath care units (hospitals, ambulances, helicopters, etc.).

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